The Recent Magnetic and Electrical Disturbances.

By Dr. C. Chree, F.R.S.

The recent magnetic and electrical disturbances have been remarkable for both their intensity and their persistence. Magnetic disturbance went on without any considerable interlude from shortly after 13h. (G.M.T.) on May 13 to 4h. or 5h. of May 17. This was followed by notable disturbances on May 19 and following days. There was, however, a distinctly quieter interval between May 17 and 19. Thus the storm was really less persistent than one presenting very similar features which began late on November 11, 1882, and continued practically without a break for nine or ten days.

As regards aurora, much depends on the season of the year, the age of the moon, and the amount of cloud. In the North of Scotland, the principal auroral region of the United Kingdom, twilight lasts so long in May that the chance of aurora being visible is but small. During the recent magnetic storm, aurora, if not generally brilliant, has been seen in a number of places. At Cambridge, aurora was seen to rise as high as the zenith on the night of May 13, and in the early morning of May 15 aurora was observed with a bright red colour. Aurora was also reported from London and other stations in southern England, where it is a rare event even at the equinoxes. Large earth-currents have been observed in the Post Office telegraph system at stations in England, Scotland, and Ireland.

The magnetic disturbances recorded at all the magnetic observatories have been of a quite exceptional nature. They reached a climax on the night of May 14–15. Almost all large magnetic storms show shorter-period oscillations superposed on changes having a more or less persistent direction for a considerable time. But the extent to which short-period oscillations prevail varies much in different storms. Also in many cases, while the disturbance of the horizontal components is considerable, the vertical force (V) shows little disturbance, and rapid oscillations of any size in that element are very rare. During the recent disturbances the persistence and size of the short-period oscillations were remarkable, and during the night of May 14–15 this characteristic was shared by V to a quite exceptional extent. The magnetic storm of November, 1882, already referred to, also showed this phenomenon, so that, though rare, it is not absolutely unique. The year 1882, it may be noted, like 1921, was not characterised as a whole by abnormal sun-spot development.

The storm has received unusual attention in the newspapers. The writer of a leading article on the subject in the *Times* of May 19 has referred to the difficulty of providing the large store of energy required, seeing no alternative to the acceptance of the estimate made many years ago by Lord Kelvin other than the giving up of the principle of the conservation of energy. As the storm considered by Lord Kelvin was very trifling compared with the recent one, the conservation of energy may appear in a hopeless case. It may thus comfort the general reader to know that a recent estimate by Prof. S. Chapman gives a result which is nearly one million-million-million times less than Lord Kelvin's. When Lord Kelvin made his estimate his position resembled that of an eighteenth-century engineer consulted as to the possibility of warming London by burning coal in the Midlands. The better the engineer of that epoch, the deeper the pessimism to be expected. But the modern engineer, familiar with high-tension electrical transmission, whatever he might think of the scheme as a financial proposition, would not consider its realisation fatal to the conservation of energy.

If, as some modern theorists have suggested, atmospheric electric potential at the earth's surface should show some response to magnetic disturbance, the morning of May 15 was the time when the phenomenon should have declared itself. Unfortunately, some rain fell that morning in London, and a decisive answer to the question must be sought elsewhere.

The Recent Large Sun-spot Group.

By H. W. Newton, The Royal Observatory, Greenwich.

The large sun-spot which appeared on May 8 is remarkable in several respects. The sun-spot cycle reached its maximum in 1917, and the occurrence of a large group some four years later, though by no means unique, is a matter of interest apart from its association with an intense magnetic storm. The spot group has been photographed daily at Greenwich, and reproductions of some of the photographs are given. Fig. 1 shows the disc of the sun on May 13, on which day the magnetic storm commenced. Fig. 2 illustrates the group in detail and the considerable changes taking place in a few days. The most interesting features of the group are (*a*) its position exactly on the sun's equator; (*b*) its abnormal development; (*c*) its position at the time of the magnetic storm.

(*a*) It is a well-established fact that the change in latitude of the sun-spots is cyclical in the same eleven-year period as their frequency. Soon after the commencement of a new cycle, spots appear mainly about latitude 25° north and south of the sun's equator. As the cycle progresses they become most numerous in successively lower latitudes, while at the present phase of the cycle they are found most frequently in latitude 10°. Very large groups on the equator are rare, however, and the present one is the largest which has appeared in this position during the last half-century. Looking at Fig. 1, it is necessary to bear in mind that at the middle of May the north end of the sun's axis of rotation is about 21° west of the north point, and that the sun's equator passes 2½° north of the centre of the disc. Spots are carried by the sun's rotation from the east to the west limb in about thirteen days. The centre of this group of spots was nearest the centre of the disc on May 14d. 16h., when it was within 3°. It was then most nearly in line with the earth, but the magnetic storm commenced twenty-seven hours earlier. The spot group was visible to the naked eye for eight out of the thirteen days it could have been seen with the telescope. Its area averaged 1/1500th part of the sun's surface, or about eight times the area of the earth, but it was only half as large as the group of spots of March, 1920.

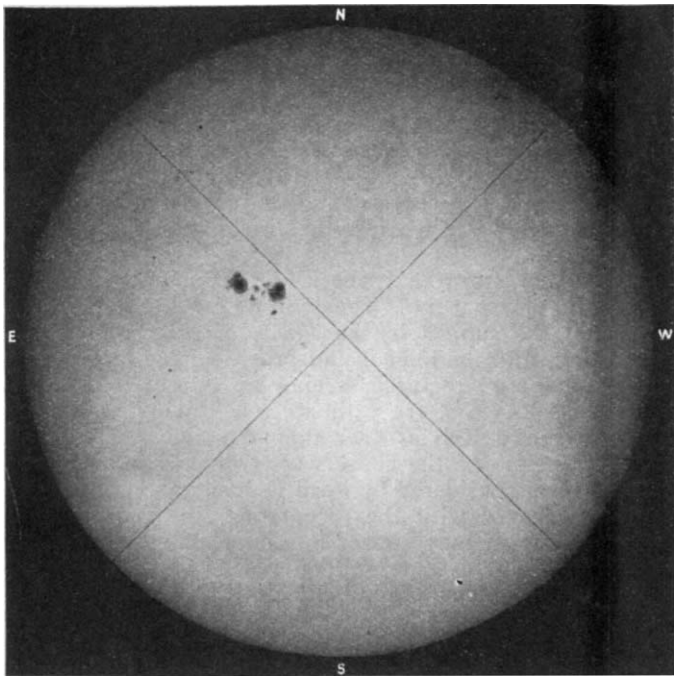

Fig. 1.—Photograph of the sun's disc on May 13d. 9h. G.M.T. Original scale 7½ in. to sun's diameter. By kind permission of the Astronomer Royal.

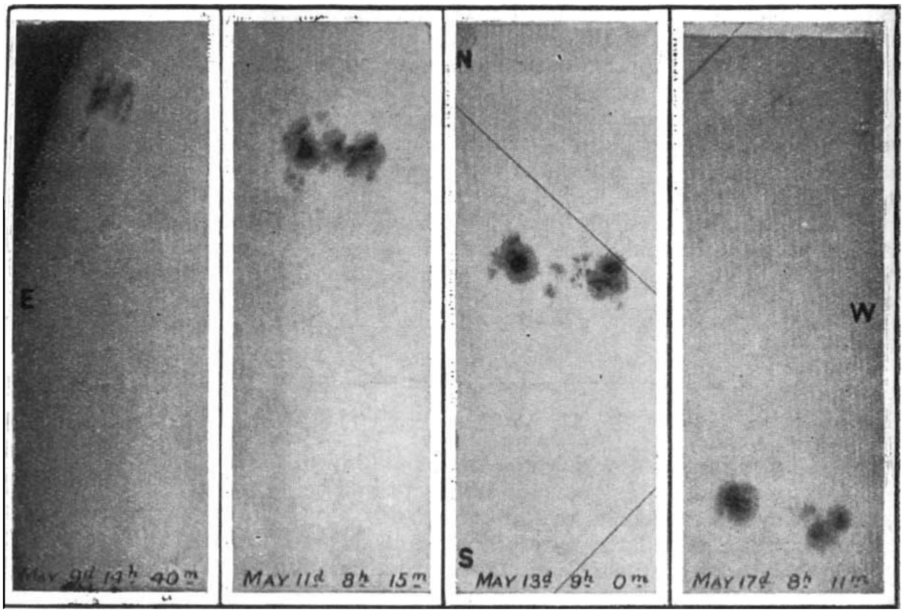

Fig. 2.—Original scale 7½ in. to sun's diameter. Note the foreshortening of the spot near the sun's limb. By kind permission of the Astronomer Royal.

(*b*) Sun-spots are nearly always to be found in continual change, especially for a few days following their formation, and it is evident from earlier photographs that this group developed after April 25, and was, therefore, of recent origin. It was first seen at the east limb of the sun on May 8 as a long, irregular spot, nearly 80,000 miles in length, with two principal nuclei; by May 13 these had become the centres of two spots 7° apart in longitude, while the mid-portion of the original spot had changed into a cluster of small ones. It is unusual for a large spot to split up in this manner. Pairs of spots often appear, but they have generally been evolved from two small nuclei. On the photograph of May 9 it will be noticed that the spot is surrounded by bright faculæ. The amount is unusually small for so large a spot, but by the time the group had reached the west limb of the sun the area of faculæ had extended considerably.

(*c*) The magnetic storm commenced suddenly at 13h. 10m. on May 13. At this time the leading spot was 11½° east of the sun's central meridian and the following spot 19°. The greatest intensity of the disturbance was about 5h. on May 15, at which time the following spot was 3° past the central meridian, while a secondary maximum followed at 8h. on May 16. It does not seem possible to associate the disturbance with one or other individual spot, but rather with the group as a whole. In this connection it is of interest to note that minor magnetic disturbances occurred on April 18 and March 21. Some years ago Mr. Maunder showed that magnetic storms tend to recur at intervals of about twenty-seven days, which corresponds to the time taken for the sun to make one rotation relative to the earth. If this sequence is continued we may expect a further disturbance on June 9, when the spot group, if still visible, will be in the same relative position on the sun's disc as on May 13, when the storm commenced.

The general relation between the diurnal variation of the earth's magnetic elements and the sun-spot cycle cannot be doubted. It is better termed the *solar* cycle, for it is well known that the solar prominences, the faculæ and flocculi, and the shape of the corona vary also with the sun-spots in the same eleven-year period. The causes, however, of this terrestrial and solar relation are still obscure, and the magnetic storms in particular offer other difficulties on account of their anomalous occurrence, although on the whole they follow the sun-spot curve. The theory which in general seems best to fit the observed facts is that which assumes a directive stream of charged particles ejected from a restricted area of the sun, most probably in the region of a sun-spot. Opinions differ as to the exact nature of the stream and as to its action on meeting the earth. It is, of course, admitted that such a stream, though it may be a requirement, is not the sole factor in the production of a magnetic storm, the energy of which is to be traced to the earth's own magnetic system, and ultimately to the earth's rotation.

At Mount Wilson Observatory the magnetic polarities of sun-spots are now investigated daily. It will be interesting to see whether this group of spots is associated with exceptionally strong or otherwise abnormal magnetic fields.

Obituary.

DR. G. B. LONGSTAFF.

DR. G. B. LONGSTAFF died on May 7, after a long period of failing health, at his residence, Highlands, Putney Heath. Dr. Longstaff was born on February 2, 1849, and educated at Rugby and at New College, Oxford, where he obtained a scholarship and a first class in natural science. At a very early age his attention was attracted to the study of insects, mainly through the influence of his uncle by marriage, William Spence, of "Kirby and Spence's Introduction to Entomology"; and he was already recognised as one of the most energetic and successful of the younger lepidopterists of his time, when a regrettable accident in the second term of his residence at Oxford, which resulted in the loss of an eye, put an end to his activities in this direction for many years. His later career at St. Thomas's Hospital, where he was awarded the Mead medal, was highly distinguished, and in later life, besides taking an active part in philanthropic and municipal work, he represented Wandsworth on the London County Council for fourteen successive years.

Much attention also was devoted by Dr. Longstaff to the scientific aspect of statistics, and his well-known work on this subject ("Studies in Statistics") was published in 1891. His long-dormant interest in entomology was revived by a tour in India and Ceylon in the winter of 1903–4; and in later years flying visits were made by him to almost every accessible part of the world in company with his accomplished second wife (*née* Mary Jane Donald, well known as an authority on recent and fossil mollusca). The energy and acumen with which insects were collected and observed on these trips may be estimated by the fact that Dr. Longstaff enriched the museum of his old university by at least 14,000 specimens, and the value of this generous contribution is greatly enhanced by the full and accurate data attached to every one of them.

The gratitude of all entomologists is also due to Dr. Longstaff for the finely illustrated and most pleasantly written narrative of these collecting trips which appeared in 1912 under the title of "Butterfly Hunting in Many Lands." The numerous and valuable observations on the bionomics of the butterflies met with in the regions visited—their flight, resting habits, seasonal forms, mimicry, and sexual scents, to which last-named subject Dr. Longstaff devoted special attention—are embodied in the last chapter of this fine book, which is supplemented by an equally valuable series of papers on the same questions by the late Fritz Müller, here presented for the first time in English.

Dr. Longstaff was a highly appreciated member of many learned bodies, and had been vice-president of the Royal Statistical Society and of the Entomological Society of London; and the loss of his commanding presence and genial address at their meetings will long be regretted by his fellow-members, as well as by his numerous friends in private life.

WE notice with much regret the announcement in the *Times* of the death of DR. EDWARD B. ROSA on Tuesday, May 17, at the age of fifty-nine years. Dr. Rosa had been connected with the U.S. Bureau of Standards since 1901, and from 1910 onward he held the position of chief physicist at the bureau.